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We have developed a model for the theoretical description of large classes of problems involving diffusive transport and mechanical relaxation in polymers undergoing glass-rubber transitions. The derivation and details of the model have been described in previous progress reports. In the final year of AFOSR support we proceeded simultaneously in two directions, namely to formulate and solve moving boundary problems for the penetrant fronts and to investigate the implications of the 'forbidden shock' regions for diffusive systems.

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We have developed a model for the theoretical description of large classes of problems involving diffusive transport and mechanical relaxation in polymers undergoing glass-rubber transitions. The derivation and details of the model have been described in previous progress reports. In the final year of AFOSR support we proceeded simultaneously in two directions.

(1) Particularly interesting and formidable were the new classes of moving boundary problems needed to describe the evolution of the penetrant front. Due to the inherent multiple time and space scales involved, similarity methods could not be used, and multi-scale techniques were devised for the full partial differential equations involved. With experience gained from developing our methods on several early simplified problems we have now successfully done physically realistic problems for both Case II and Super-Case II diffusion into a glassy polymer. We have isolated the parameter dependencies and controlling factors for the propagating diffusive fronts.

(2) Certain polymer-penetrant problems give rise to unusual nonlinear, non-Fickian diffusion alone or in combination with mechanical relaxation and/or reaction. The unusual nature of these new problems comes from the form of the conditions at fixed and moving boundaries. Preliminary results obtained by T. P. Witelski in his thesis research for D. S. Cohen indicated that evolution equations with interesting time dependent forcing account for the propagation of sharp interfaces and the formation of shocks. This time dependence is introduced from the original boundary conditions even when there is no time dependent forcing in the original equations. We have pursued this and studied the process by which the time dependence causes subtle changes in the shock formation process, including the creation of "forbidden regions" where shocks are expected from the more usual studies of reaction-diffusion equations subject to standard mathematical boundary conditions, but where they can not form in the present problems. This will have serious implications with regard to the fabrication and design of many polymeric materials.

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CONTRIBUTED PAPER (oral presentation)
S. Xiong, C. Durning, D.S. Cohen, "Swelling and Collapse of Elastic Shells," paper 7i, 1996 Spring National Meeting of the AIChE, New Orleans LA, Feb. 1996.

CONTRIBUTED PAPER (oral presentation)
C. Durning, S. Xiong, D.S. Cohen and D.A. Edwards, "Swelling and Collapse of Elastic Shells," paper 1 session FM-E, XIIth International Congress on Rheology, Quebec CA, August 1996.

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C.J. Durning, S. Xiong, D.S. Cohen and D.A. Edwards, "Swelling and Collapse of Elastic Shells," Proc. XIIth Int. Congress on Rheology, A. Ait-Kadi, J.M. Dealy, D.F. James and M.C. Williams eds., Laval University Press, Quebec CA (1996), p.343.

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